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Monthly Report

June 1987 Number 226

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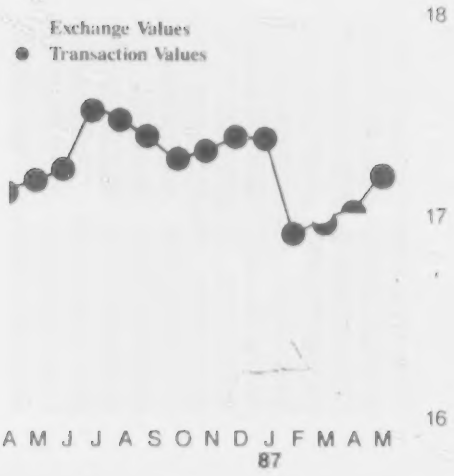

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NUEXCO REPORT 226 FIGURES OF THE MONTH (May 31, 1987)	This Month (Report 226)	Last Month (Report 225)	12 Months Ago (Report 214)
Exchange Value[1]	17.00	17.00	17.00
Transaction Value[1]	17.20	17.00	17.15
UF_6 Value[2]	47.75	48.00	48.25
Loan Rate[3]	3%	3%	4%
Conversion Value[4]	1.80	1.80	1.80
Near-Term Uranium Supply[5]	4.1	4.5	4.2
Near-Term Uranium Demand[6]	1.4	0.6	1.0
Near-Term Supply-Demand Ratio	3.0	7.8	4.3
Recent Uranium Sales:			
Number of Transactions[7]	6	10	6
Quantity of Material[8]	5.3	4.1	1.2
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	75	77	75
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00[13]	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U^{235}	450	455	450
3.0 w/o U^{235}	575	582	575
3.5 w/o U^{235}	702	711	702
4.0 w/o U^{235}	831	842	831

[1]US $ per pound U_3O_8 equivalent.
[2]US $ per kilogram U as UF_6.
[3]Per annum.
[4]US $ per pound U as UF_6.
[5]Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).
[6]Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).
[7]Uranium sales only; does not include loans, conversion, or SWU transactions.
[8]Millions of pounds U_3O_8, equivalent.
[9]US $ per SWU.
[10]Effective 10/1/86.
[11]Effective 10/1/85.
[12]Effective 10/1/84.
[13]Effective 10/1/86, for up to 30% of annual requirements.
[14]Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.
[15]US $ per KgU as UF_6, rounded to the nearest $.

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EXECUTIVE SUMMARY
REPORT 226
(All data as of May 31, 1987)

Exchange Value $17.00, unchanged

The **Exchange Value** is **$17.00** per pound U_3O_8, unchanged since last month.

UF_6 Value $47.75, down 0.25

The **UF_6 Value** is **$47.75** per kilogram U as UF_6, down 0.25 since last month.

Transactions

Four recent natural uranium sales are reported, involving **5.1 million** pounds equivalent U_3O_8. Three of the sales involved spot or near-term delivery, and met the conditions for inclusion in the Transaction Value. Two transactions also are reported involving low-enriched UF_6, totaling approximately 250,000 pounds equivalent U_3O_8.

Supply-Demand Ratio decreased to 3.0:1

Active spot and near-term **uranium supply** amounts to **4.1 million** pounds U_3O_8 equivalent, down **415 thousand pounds** since last month. Active spot and near-term **uranium demand** totals **1.4 million** pounds, up **800 thousand** pounds from last month. The spot and near-term **supply-demand ratio decreased** to **3.0:1.**

Transaction Value $17.20, up $0.20

The **Transaction Value** is **$17.20** per pound U_3O_8, **up $0.20** since last month. The calculation includes 17 transactions involving a total of 3.1 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.

Loan Rate unchanged at 3%

The **Loan Rate** is **3 percent** per annum, unchanged.

Conversion Value $1.80, unchanged

The **Conversion Value** is **$1.80** per pound U as UF_6, **unchanged** since last month. Active secondary market supply for conversion services for delivery within three years totals **580** thousand pounds U as UF_6. No active demand is listed this month. No secondary market conversion transactions are reported.

SWU Value for delivery within one year: $75, down $2.00

The **SWU Value** at .3 tails and for delivery within one year is **$75** per SWU, down $2.00 since last month. Two secondary market SWU transactions are reported.

* * *

Analysis and Commentary

The secondary market for enrichment services is expected to remain relatively dormant through the early 1990s. Uncommitted SWU requirements will remain at a level of under one million SWU per year until about 1990, increasing to about four million SWU per year by 1995. After 1995, excess production capacity and uncommitted requirements could gradually increase the volume of SWU sold on the secondary market.

Basic Considerations

Decommissioning of nuclear power plants will become increasingly necessary in coming years, as many plants approach the end of their operating lives. Part One of this article examines future trends in numbers of plants to be decommissioned, alternative decommissioning strategies, and some social issues that could affect decommissioning schedules.

Japan

Annual price negotiations concluded between several Japanese utilities and South Africa's Nuclear Fuels Corporation (NUFCOR) for uranium delivered under long-term contracts, have concluded with an agreed price of US $30.50 per pound U_3O_8, unchanged since the previous year. In other developments, Tokyo Electric Power Company (TEPCO) announce plans to begin construction of two new advanced BWRs in 1991 and 1993, respectively. General Electric Corporation of the USA will provide part of the plant equipment.

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MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

June 1987 No. 226

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

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To Our Readers

We are pleased to announce that Mr. Hans W. Vogt has accepted appointment to Nuexco's International Advisory Committee. Mr. Vogt has been involved in the nuclear power industry since the 1960s, after receiving his degree in Electrical Engineering at the Swiss Federal Institute of Technology in Zurich, and he has extensive experience both in Europe and in the USA. He was formerly director in charge of construction and plant startup of the Gösgen nuclear plant, and later served as director of the plant's nuclear fuel management and supply operations. Mr. Vogt also has been involved in evaluating bids for the Kaiseraugst nuclear plant, and very recently has accepted the position of President of EAO-Holding Company: Lumipost AG, an electrical-mechanical manufacturing company in Olten, Switzerland.

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NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of May 31, 1987)

The **Exchange Value** is **$17.00** per pound U_3O_8, unchanged since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **4,080,000** pounds U_3O_8 equivalent, down 415 thousand pounds since last month. The corresponding figure for **active demand** is **1,375,000** pounds, up 800,000 pounds. The spot and near-term **supply-demand ratio** decreased to **3.0 to 1.**

The *Current Market Data* section of this Report lists four natural uranium concentrate sales, totaling 5.1 million pounds U_3O_8 equivalent. In addition, two transactions involving low-enriched UF_6 are reported, totaling 250,000 pounds equivalent U_3O_8. US-origin uranium is commanding a premium (relative to the Exchange Value) of $0.90 per pound U_3O_8 (down $0.60) in the form of concentrates, and $2.25 per kilogram U (down $0.75) in the form of UF_6.

The **Transaction Value** is **$17.20** per pound U_3O_8, up $0.20 since last month. The calculation extends over a 3-month period and includes 17 transactions involving 3.1 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$47.75** per kilogram U in UF_6, down $0.25 since last month. Canadian sellers have become somewhat more aggressive, after missing some recent market opportunities.

The **Conversion Value** is **$1.80** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 580 thousand pounds U as UF_6. No active demand is reported this month. No secondary market conversion transactions are reported.

The **Loan Rate** is **3 percent** per annum, unchanged.

* * *

The Exchange Value remained at $17.00 this month. Activity in the spot and near-term markets for U_3O_8 diminished in May, as compared to the last several months. One long-term sale to a European utility which was negotiated earlier in the year, is reported, totaling over 4.7 million pounds, and three other buyers concluded U_3O_8 spot purchases. Altogether, transactions involving more than 5.3 million pounds U_3O_8 equivalent were concluded during May. The supply-demand ratio has declined since last month, as supply decreased slightly and demand increased due to recent inquiries by US and European utilities.

The uranium market remains fragmented because of legislative, judicial and political factors; origin and physical location of material are still the prime determinants of price. The main factors are the still unresolved US Producers vs. DOE lawsuit, the US Anti-Apartheid Act of 1986, new legislation proposed in the US Congress, the Canadian upgrading policy, and various restrictions on end use due to non-proliferation concerns.

The premium (relative to the Exchange Value) for US-origin concentrates declined $0.60 to a new level of $0.90 per pound U_3O_8. Of the three spot natural uranium sales reported this month, two involved US-origin uranium and totaled less than 200 thousand pounds U_3O_8. Demand for US-origin concentrates remains weak, and some small lots of US-origin material are available at prices slightly below those offered for larger quantities. For significant quantities of US mine-origin uranium, prices asked by US producers remain higher than the sum of the Exchange Value and the premium (i.e. the incremental price commanded by US-origin material in transactions where the buyer restricts the acceptable origin to US), and higher than US-origin created through swaps or sold from traders' stocks.

Because of the uncertainty surrounding the origin issue, US utilities have substantially reduced levels of non-US-origin uranium in inventory. As a consequence, the demand for swaps into US-origin has fallen, and swap fees have dropped below the current premium for US origin. The distinction currently being made by some buyers of US-origin material between mine-origin uranium and that created through flag swaps has added downward pressure on swap fees.

Since the original decision in the US Producers vs. DOE lawsuit in June 1986, and DOE's subsequent appeal to the Tenth Circuit Court of Appeals, rumors of an imminent court decision have periodically circulated through the uranium industry. Nuexco has received, and continues to receive almost on a daily basis, inquiries regarding the status of the court case. But since there is no way of predicting when such a decision will be made (nor its outcome), near-term financial pressures on US producers have been at odds with the producers' hope of a favorable judgment, and their desire to hold out for prices in excess of the Exchange Value plus the US premium.

Based on actions taken since Judge Carrigan's original ruling, it is clear that market participants anticipate that the original ruling will be upheld by the Appellate Court. As noted above, US utilities generally have done whatever they could to reduce the non-US fraction of their inventories, in case of a partial or total restriction on the use of imported

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CURRENT MARKET DATA

uranium. Most have maximized their use of non-US-origin feed and continue to do so. Techniques include the purchasing of non-US material in order to save stocks of US-origin for use after the likely imposition of a limitation on the use of non-US-origin uranium. Some US utilities buying non-US uranium in the long-term market have included contract provisions that excuse them from purchasing to the extent that non-US-origin material cannot be used. Others have made use of internal or external location and origin swaps (including de-enrichment swaps) some of which have strained the regulatory process. Still others have simply bought US-origin and paid the premium, to ensure against later potential supply shortages or rapid price increases. Other entities, including non-US utilities, producers and traders also have made adjustments, and concluded transactions, in ways that presume restrictions on the import of non-US uranium.

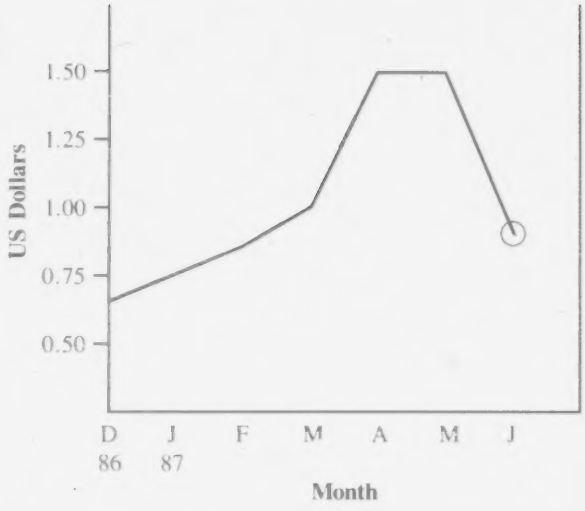
Since there are as yet no *legal* requirements restricting the import of non-US-origin uranium into the USA, other than those imposed against southern African uranium as a result of the Comprehensive Anti-Apartheid Act of 1986, the US premium reflects buyers' and sellers' perceptions of future market conditions and events. The movement of the US premium (Figure 1) since it was introduced in December 1986 (Report 220) shows several market phases. First, the rise in premium reflects the emergence of preferred or required purchasing of US-origin by US utilities. The leveling off reflects the attainment of an equilibrium condition, and the subsequent decline reflects the fall-off in demand for US-origin associated with a gradual lessening of tension as the court decision continued unresolved, and US utility inventory became largely of US origin. The factors with the greatest influence over the premium for US-origin uranium remain the decision by the Appeals Court, and possible legislative action that would restrict imports.

* * *

The UF_6 Value declined $0.25 this month, to $47.75 per kgU as UF_6. No transactions are reported involving natural UF_6, but two sales of low-enriched UF_6 were concluded, totaling over 250,000 pounds U_3O_8 equivalent. Demand for natural UF_6 remains unchanged since last month. Although available sales opportunities are relatively few, sellers appear slightly more aggressive than in past months, and the largely

Figure 1

U S PREMIUM
(Relative to Exchange Value)



discretionary demand has resulted in a slight downward price movement. US-origin UF_6 still is relatively more abundant than US-origin U_3O_8. The premium (relative to the UF_6 Value) for US-origin UF_6 declined $0.75 to $2.25, following the general weakening in prices for US-origin material.

* * *

The Loan Value remained unchanged this month, at three percent. No loan transactions are reported. While some loan opportunities exist, the security requirements imposed by potential lenders on financially marginal borrowers have served to make most potential transactions uneconomic.

* * *

The Conversion Value is unchanged since last month at $1.80. No conversion transactions are reported, and the secondary market for conversion services remains relatively inactive. Supply of secondary market services is unchanged since last month, and what demand does exist is largely discretionary as to timing.

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ENRICHED URANIUM AND SWUS

The SWU Value declined to $75 per SWU this month. Two SWU transactions, totaling less than 100 thousand SWU, are reported in the *Current Market Data* section of the Report, all from purchases of low-enriched uranium. Weak demand caused a slight downward price pressure on the secondary SWU market during May, with only one buyer whose timing is discretionary in the market for a significant quantity of SWU. A number of potential sellers have yet to enter the market, and some are constrained by noncommercial factors from offering their SWU. They could enter the market at any time, adding substantial new quantities for sale. Any such entry could result in further downward pressure on SWU prices in the near future.

DOE-origin SWU currently is selling at a discount compared to Eurodif or Urenco SWU, because of concerns about a potential embargo on feeding non-US uranium for enrichment. European enrichers will likely always be able to take non-US-origin feed, while an embargo could limit the amount of non-US feed allowed for delivery to DOE for enrichment. In addition, prices of USSR-origin SWU remain significantly below those for western-origin SWU.

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CURRENT MARKET DATA

May 31, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$17.00**/lb. U_3O_8	4,080	1,375
UF_6 VALUE	**$47.75**/kgU		
CONVERSION VALUE	**$1.80**/lb. U as UF_6	580	0
SWU VALUE 0.3 tails assay; delivery within one year	$75/SWU		
LOAN RATE	3%/annum	1,000	500

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**17.20**	3.1	17	3

[1]Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow; and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

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EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (May 31, 1987)	Last Month (Apr 30, 1987)	12 Months Ago (May 31, 1986)	This Month (May 31, 1987)	Last Month (Apr 30, 1987)	12 Months Ago (May 31, 1986)
Australia (dollar)	23.84	26.15	23.64	61.97	67.97	61.47
Belgium (comm. franc)	640.30	631.50	796.25	1,665	1,642	2,070
Canada (dollar)	22.84	22.73	23.41	59.37	59.09	60.86
EEC (ecu)	14.90	14.72	18.04	38.75	38.26	46.92
Finland (markka)	74.79	74.46	89.62	194.44	193.59	232.98
France (franc)	102.97	101.49	124.82	267.69	263.86	324.49
FRG (mark)	30.82	30.45	39.21	80.12	79.16	101.93
Italy (lira)	22,269	21,778	26,759	57,894	56,618	69,567
Japan (yen)	2,433	2,366	2,923	6,326	6,152	7,599
Netherlands (guilder)	34.76	34.39	43.93	90.36	89.41	114.20
South Africa (rand)	34.34	34.03	39.44	89.29	88.48	102.54
Spain (peseta)	2,151	2,140	2,484	5,591	5,563	6,457
Sweden (krona)	107.59	106.65	123.91	279.72	277.27	322.13
Switzerland (franc)	25.55	24.96	32.46	66.43	64.88	84.39
UK (pound)	10.43	10.24	11.42	27.11	26.62	29.68
US (dollar)	17.00	17.00	17.00	44.20	44.20	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (May 31, 1987)	Last Month (Apr 30, 1987)	12 Months Ago (May 31, 1986)	This Month (May 31, 1987)	Last Month (Apr 30, 1987)	12 Months Ago (May 31, 1986)
Australia (dollar)	24.12	26.15	23.85	67.70	67.97	62.01
Belgium (comm. franc)	647.83	631.50	803.28	1,684	1,642	2,088
Canada (dollar)	23.11	22.73	23.62	60.07	59.09	61.40
EEC (ecu)	15.08	14.72	18.20	39.20	38.26	47.33
Finland (markka)	75.67	74.46	90.41	196.73	193.59	235.04
France (franc)	104.18	101.49	125.92	270.84	263.86	327.36
FRG (mark)	31.18	30.45	39.55	81.07	79.16	102.83
Italy (lira)	22,531	21,778	26,995	58,575	56,618	70,181
Japan (yen)	2,462	2,366	2,949	6,401	6,152	7,666
Netherlands (guilder)	35.17	34.39	44.32	91.43	89.41	115.21
South Africa (rand)	34.75	34.03	39.79	90.34	88.48	103.45
Spain (peseta)	2,176	2,140	2,505	5,657	5,563	6,514
Sweden (krona)	108.86	106.65	125.00	283.01	277.27	324.97
Switzerland (franc)	25.85	24.96	32.75	67.21	64.88	85.14
UK (pound)	10.55	10.24	11.52	27.43	26.62	29.94
US (dollar)	17.20	17.00	17.15	44.72	44.20	44.59

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on May 29, 1987.

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CURRENT MARKET DATA

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF_6			per kg. U as UF_6		
	This Month (May 31, 1987)	Last Month (Apr 30, 1987)	12 Months Ago (May 31, 1986)	This Month (May 31, 1987)	Last Month (Apr 30, 1987)	12 Months Ago (May 31, 1986)
Australia (dollar)	2.52	2.77	2.50	5.56	6.10	5.52
Belgium (comm. franc)	67.80	66.86	84.31	149.47	147.41	185.87
Canada (dollar)	2.42	2.41	2.48	5.33	5.31	5.46
EEC (ecu)	1.58	1.56	1.91	3.48	3.44	4.21
Finland (markka)	7.92	7.88	9.49	17.46	17.38	20.92
France (franc)	10.90	10.75	13.22	24.04	23.69	29.14
FRG (mark)	3.26	3.22	4.15	7.19	7.11	9.15
Italy (lira)	2,358	2,306	2,833	5,198	5,084	6,246
Japan (yen)	257.66	250.56	309.49	568.04	552.38	682.31
Netherlands (guilder)	3.68	3.64	4.65	8.11	8.03	10.25
South Africa (rand)	3.64	3.60	4.18	8.02	7.94	9.21
Spain (peseta)	227.70	226.56	262.97	502.00	499.47	579.74
Sweden (krona)	11.39	11.29	13.12	25.12	24.90	28.92
Switzerland (franc)	2.71	2.64	3.44	5.96	5.83	7.58
UK (pound)	1.10	1.08	1.21	2.43	2.39	2.67
US (dollar)	1.80	1.80	1.80	3.97	3.97	3.97

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	SWU VALUE delivery within one year (May 31, 1987)	UF_6 Value per kg.U in UF_6 This Month (May 31, 1987)	UF_6 Value per kg.U in UF_6 Last Month (Apr 30, 1987)
Australia (dollar)	105.16	66.95	73.82
Belgium (comm. franc)	2,825	1,798	1,783
Canada (dollar)	100.75	64.14	64.17
EEC (ecu)	65.76	41.86	41.55
Finland (markka)	329.96	210.07	210.24
France (franc)	454.27	289.21	286.56
FRG (mark)	135.97	86.56	85.97
Italy (lira)	98,245	62,549	61,491
Japan (yen)	10,736	6,835	6,682
Netherlands (guilder)	153.34	97.62	97.10
South Africa (rand)	151.52	96.46	96.09
Spain (peseta)	9,488	6,040	6,042
Sweden (krona)	474.68	302.21	301.12
Switzerland (franc)	112.73	71.77	70.46
UK (pound)	46.01	29.29	28.90
US (dollar)	75.00	47.75	48.00

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on May 29, 1987

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RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
4038	1988	101-300	R[5]	Trader	Utility	Low-enriched UF_6
4045	1989-98	3,001-6,000	R[5]	Producer	Utility	
4051	1988	50-100	113	R[5]	Utility	US-origin.
4058	1988	101-300	103	Producer	Utility	
4059	1988	50-100	R[5]	Trader	Utility	Low-enriched UF_6
4060	1987	50-100	104	Producer	Utility	US-origin.

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2]If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.
[3]Prices are usually normalized to 0.3% tails assay.
[4]Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.
[5]The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
4038B	1988	50-100	R[5]	Trader	Utility		Low-enriched UF_6
4059B	1988	less than 50	R[5]	Trader	Utility		Low-enriched UF_6

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2]If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.
[3]Prices are usually normalized to 0.30% tails assay.
[4]Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.
[5]The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

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CURRENT MARKET DATA

URANIUM SUPPLY
(May 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2335	420	—	
2764	500	—	
2893A	720	—	UF_6
2933	300	300 per year	1988-90
2989	40	—	
2996*	200	500 per year	1988-90
3023	400	500	UF_6
3121*	500	—	
3166	50	—	
3238*	500	—	1988-90
3244*	250	300 per year	1988-93
3316*	200	—	
2263	—	400 per year	1989 on
2781	—	400 per year	1988-95
3123	—	2,000	1988
3171	—	200 per year	1988-92
TOTAL:	4,080		
INACTIVE			
2297	100	100 per year	1988-89
2967	1,000	—	
3168	50	100 per year	1988-92
2336	—	200 per year	1988-94
2625	—	500 per year	1988 on
2981	—	600 per year	1988-91
3128	—	100	1988 on
TOTAL:	1,150		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2389, 2740, 2973, 3129, 3135.

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URANIUM DEMAND
(May 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2890	175	—	
2911*	65	—	UF_6
3141*	130	—	
3149*	50	—	
3175	90	—	UF_6
3191*	390	—	
3216*	325	—	U_3O_8 or UF_6
3249*	150	—	
2738	—	1,000	1989 on
2936	—	400 per year	1988-95
2962	—	500 per year	1988 on
2985	—	675 per year	1992 on
3120	—	1,000 per year	1988-91
3137	—	4,800 per year	1993-97
3147	—	200	1988-92
3193	—	700 per year	1989,91,94,96
TOTAL:	1,375		
INACTIVE			
2798	150	—	
2984*	260	—	U_3O_8 and UF_6
TOTAL:	410		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2760, 3192.

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CURRENT MARKET DATA

LOAN SUPPLY AND DEMAND
(May 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U3O8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan			
ACTIVE			
2909	1,000	—	
TOTAL:	1,000		
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2912	1,000	—	
2920	2,000	—	
TOTAL:	5,500		
Inquiries to borrow			
ACTIVE*			
3206	500	—	
TOTAL:	500		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: None.

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CONVERSION SUPPLY AND DEMAND
(May 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale: ACTIVE			
3222	80	—	
2764B	500	—	
TOTAL:	580		
Available for Sale: INACTIVE			
2859	750	750	
3165	330	—	
TOTAL:	1,080		
Inquiries to Purchase: INACTIVE			
2833	400	—	
2997	650	—	
TOTAL:	1,050		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: 2988.

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CURRENT MARKET DATA

SWU SUPPLY AND DEMAND
(May 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2571	55	—	1987
3173	45	—	1987
TOTAL:	100		
INACTIVE			
3213	150	—	
3322	150	—	
TOTAL:	300		
Inquiries to Purchase:			
ACTIVE			
2999	150	—	1987
3159	30	—	1987
TOTAL:	180		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2969, 3159, 3208.

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THE SECONDARY SWU MARKET IN THE 1990s

This article is an edited version of the speech given by Nuexco's Don W. Radcliffe, at the AIF International Conference: The Enrichment Marketplace in the 1990s, *in San Francisco, California, May 28, 1987.*

Introduction

The secondary market for enrichment services originated as a means to solve imbalances arising from plant cancellations and delays, which had been aggravated by DOE's inflexibility in allowing contract holders to reduce their commitments. The market grew as Eurodif shareholders sought an outlet in the USA for their excess commitments, helped by the strong position of the dollar versus European currencies. In 1983-1984, the US Department of Energy (DOE) introduced various versions of enrichment contracts, finally settling on the Utility Services enrichment contract (USEC). The overwhelming customer response to the USEC temporarily halted DOE's loss of market share to the secondary market and to Eurodif, and reduced the number of both buyers and sellers on the secondary market. DOE's competitive situation also was helped by the fall of the dollar, which has effectively reduced the flow of Eurodif SWU into the USA.

The secondary SWU market is expected to evolve into a "spot" market for excess capacity of primary producers after about 1990, when most currently identified excess SWU inventories should be sold. Major uncertainties exist, however, regarding DOE's future prices, and possible judicial or legislative intervention in the US enrichment business. The potential entry of private SWU suppliers adds another variable into the future situation.

Origins of the Secondary Market

The secondary SWU market began in the mid-1970s with DOE's assignments of Long-Term Fixed Commitment (LTFC) contracts. At the time, DOE (formerly the AEC) held a virtual world monopoly, and had ceased taking orders for new contracts, leaving a substantial number of planned nuclear plants with no enrichment supply. As units with LTFCs began to be canceled, a lively trade developed in assigning the contracts from the canceled units to those lacking contracts.

The next phase of the secondary market followed DOE's "open season" in 1975 and the change to the Adjustable Fixed Commitment (AFC) contract in 1978. Because the AFC required utilities to agree to five-year advance commitments, plant construction delays and cancellations created many excess commitments. To relieve the pressure, DOE allowed its AFC customers to reduce their commitments by the equivalent amount of DOE SWU bought on the secondary market. This created the demand necessary to fully establish a secondary market, and led to a number of deals to swap future delivery commitments, partly spurred by the desire of utilities with delayed plants to recoup advance payment credits. Secondary market prices were keyed to the DOE AFC prices, and discounts of $2 to $5 per SWU were common.

By 1980, numerous new plant cancellations and delays overwhelmed the near-term demand for SWU. Burdened with development costs, DOE failed to respond to this trend, maintaining high production levels, and refused to provide relief to AFC contract holders. This created a large inventory of excess SWU and a buyers' market with increasingly large discounts. Once these discounts reached about $30 per SWU, holders of DOE's 3.5-year requirements contract realized they could terminate their DOE deliveries, pay the 25 percent termination charges, and still benefit from buying on the secondary market. When contract holders also began to realize that by going short and terminating their requirements contracts ahead of time, they could save the termination charges, contract terminations started to snowball. Even some 5-year requirements contract holders used the technique, through creative accounting on their contract delivery ceilings.

As DOE watched its planned enrichment commitments slip away, trends in Europe further eroded DOE's market. With Eurodif running at high capacity, Europeans also developed inventories of excess SWU. Some Europeans took advantage of the then strong dollar to sell into the DOE market.

Initially, US utilities saw the purchasing and use of non-US SWU as risky. The market in European enrichment started slowly, with high discounts and requirements to stockpile SWU in the USA. As sellers of Eurodif SWU established their credibility, increased US buying cost DOE 25 percent of its market share. DOE responded by offering the Interim Sales Contract, which allowed requirements contract holders a reduced price if they would stay with DOE, but this just triggered another round of price cuts by European sellers.

DOE's next attempt to keep its position was the Modified Interim Sales Contract, which permitted requirements contract holders to buy 40 to 60 percent of their needs on the

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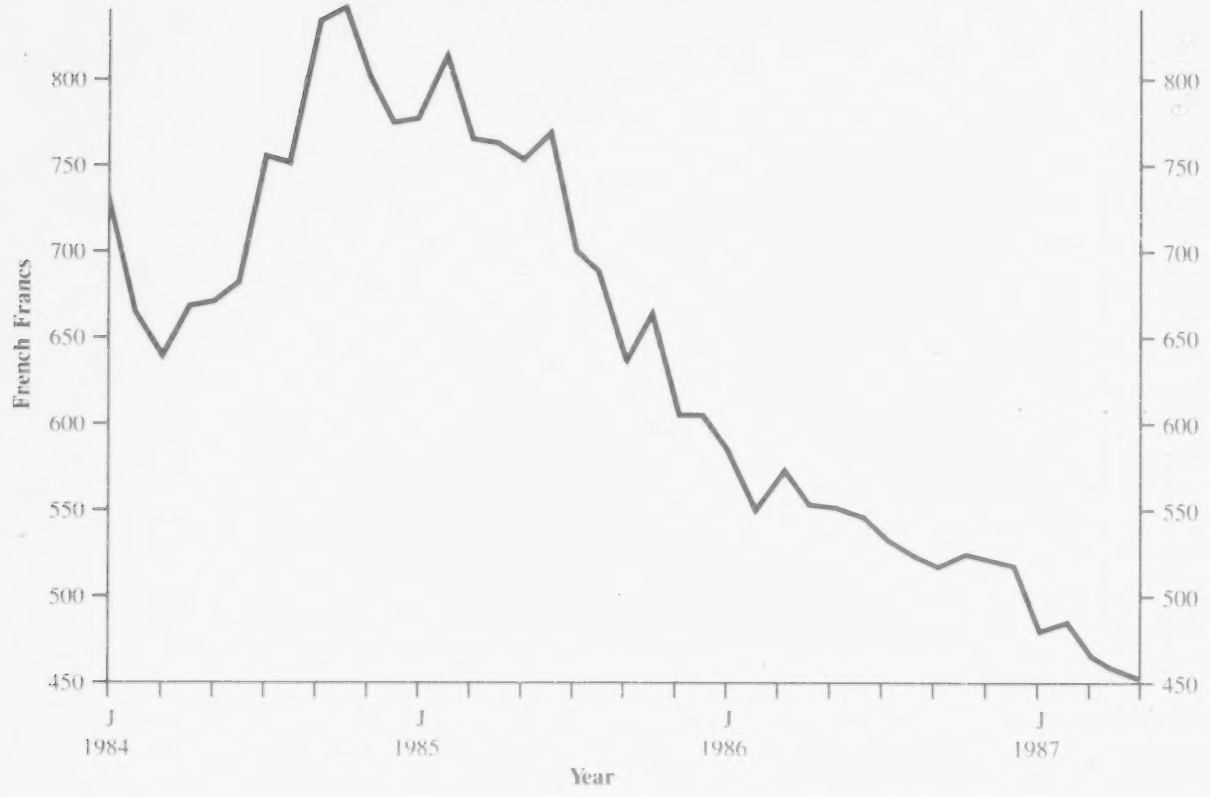
ANALYSIS & COMMENTARY

Figure 2

SECONDARY MARKET SWU PRICES
(NUEXCO SWU VALUES)
EXPRESSED IN FRENCH FRANCS and US DOLLARS



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secondary market without termination penalties, as long as the SWU were certified to be DOE origin, but this offer also met with limited success.

In 1984 DOE made four major changes, embodied in the new Utility Services Enrichment Contract (USEC):

1. higher termination charges;
2. reduced prices and a guaranteed price ceiling;
3. requirements-based contracting to eliminate excess SWU; and
4. allowance for customers to buy up to 30 percent of their requirements outside DOE.

Customer acceptance of the USEC exceeded even DOE's projections, representing over 80 percent of DOE customers and covering more than 90 percent of their projected demand. The following year, DOE succeeded in removing most of its customers' uncommitted requirements from the secondary market through the Incentive Price SWU offer. The Incentive Price offer allowed DOE customers to fill their uncommitted requirements from DOE at $90 per SWU for 1987 and 1988 deliveries, and $90 with escalation for 1989 and 1990. To further consolidate its market share, DOE made a second Incentive Price offer at $85 per SWU plus escalation for 1991 to 1995 deliveries. While not as successful as the first, the second offer still was accepted by a majority of DOE's customers.

The USEC has been called an "overkill" solution, as the supply of Eurodif-origin SWU for sale on the secondary market already had been decreasing as the new terms were introduced. Considering that the USEC's introduction has cut DOE's annual revenues by over 40 percent, it is not surprising that customers found it attractive, particularly the AEC customers.

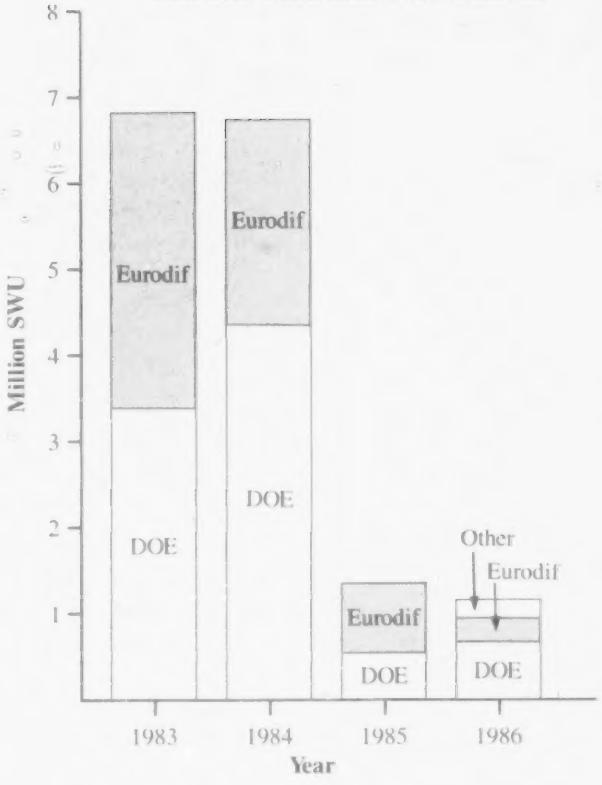
Since introduction of the USEC, DOE's competitive position has been helped by the drastic decline of the US dollar against the European and Japanese currencies since 1984. Figure 2 shows the 40 percent fall in secondary market prices since 1984 as expressed in terms of the French franc. Secondary market SWU prices expressed in other European currencies declined similarly. While in 1983, Eurodif shareholders were motivated to sell because they could receive prices above their incremental costs of production, this situation currently is reversed, with DOE incentive prices below Eurodif production costs.

The Future of the Secondary Market

Given the success of the USEC in eliminating the majority of secondary market buyers and sellers, what is the future of the secondary SWU market? Compared to the peak activity of 1983 and 1984, the market is relatively quiet. As shown in Figure 3, annual sales in the secondary market dropped from over six million SWU in 1983 and 1984 to about one million SWU in 1985 and 1986.

Figure 3

SECONDARY SWU MARKET
ANNUAL TRANSACTION VOLUME



Today's secondary SWU market is a buyers' market, with demand from the few utilities which have uncontracted requirements outweighed by the available supply of secondary market SWU. Assuming no cancellations of existing contracts, uncontracted requirements are expected to absorb less than one million SWU per year through 1990, with the majority of this demand coming from US utilities (Figure 4). After 1990, DOE customers that did not accept the second incentive price offer, plus Eurodif, Urenco, and Techsnabexport customers whose contracts expire, gradually will

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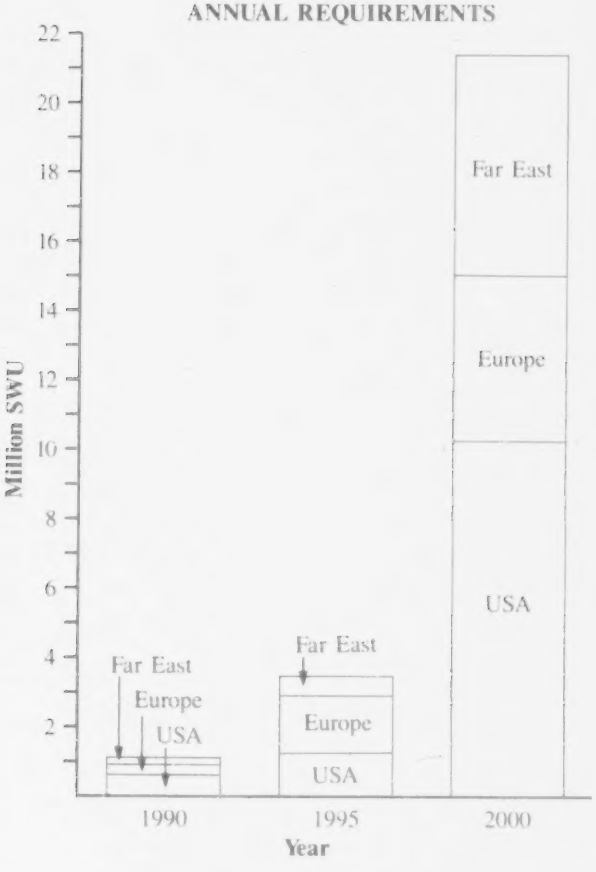
Figure 4

UNCONTRACTED SWU ANNUAL REQUIREMENTS



increase the potential demand to about four million SWU per year in 1995. Many of these customers are committed to national suppliers, and are expected to extend existing contract obligations. After 1995, however, nearly two-thirds of the western world's SWU demand, or over 20 million SWU per year, still is not committed and could be purchased on the the spot or secondary market.

The sellers in today's market are those that hold excess inventory or delivery commitments, plus primary producers such as the USSR, that are willing to sell on the spot market. There are about 25 million SWU currently in utility inventories, representing approximately one year's requirements for the entire western world. Of these SWU, from 2 to 5 million are likely to be sold as excess in the next five years. The quantity sold will depend largely on customers' expectations of future DOE pricing policy; if those customers expect prices to maintain the current downward trend, more utilities will decide to sell. The USSR's enrichment export company, Techsnabexport, also is active in the spot market, selling primarily to European customers. Buying SWU from the USSR is viewed as risky by some utilities, in the same way as buying European SWU appeared risky in the early 1980s. However, the USSR's costs are perhaps the lowest in the world, their prices are attractive, and a history of reliable deliveries will help break down these perceived barriers.

After 1990, most of the currently identified excess inventories should be sold, and to the extent it exists, the "secondary" SWU market will likely evolve into a "spot" market for primary SWU suppliers with excess production capacity. The current Eurodif shareholder contracts are due to be renegotiated for deliveries after 1990. Today, it is uncertain whether Eurodif production will continue at reduced levels, or whether shareholders with reduced nuclear programs will emerge from these negotiations with additional SWU that must be sold on the secondary market.

Conditions in the 1990s should be more favorable for secondary market sellers, but the DOE incentive price probably will still put an upper limit on secondary market pricing. Excess production capacity will exist through the end of the century, even without further capacity additions (Figure 5). Any additional privately produced SWU will add to the excess capacity and will have to displace current production capacity.

While the above forecasts of supply and demand would indicate that the secondary market will play a relatively small role in the 1990s, it is probable that the primary SWU market will be inefficient enough to create additional opportunities. On closer inspection, the foregoing forecasts rest on unstable economic and political ground. For example, most of the customers who converted to the USEC are satisfied with results to date, but now are concerned with the future of the DOE enrichment enterprise.

Major uncertainties for USEC contract holders include DOE's debt repayment and TVA's demand charges, which could cost up to $10 billion. While DOE has reduced prices over the last few years to support their market strategy, it is hard to see how DOE can continue doing this. DOE's current price structure is based on liquidating inventories that were produced in previous years at lower costs. Those inventories are predicted to run out after FY88, leading to a potential cash flow crisis if the TVA situation is not resolved, and DOE is again asking Congress for assistance.

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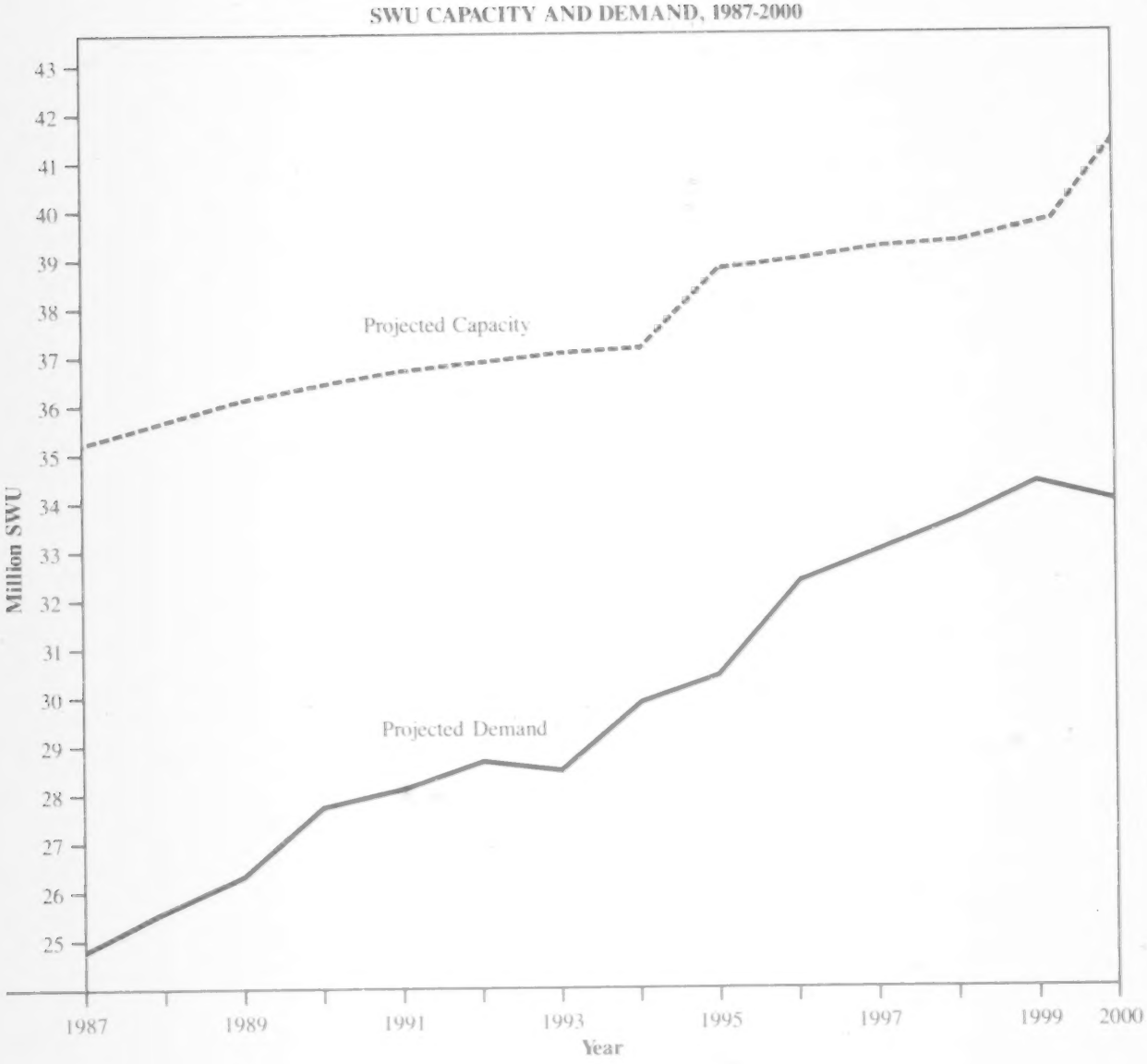
Figure 5

SWU CAPACITY AND DEMAND, 1987-2000



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In addition to price concerns, there are pending sanctions and court cases which could limit or prohibit DOE from enriching non-US-origin uranium for US customers and southern African uranium for non-US customers. Even some US utilities are questioning the reliability of DOE as a supplier and demanding discounts for secondary market DOE-origin SWU. If the potential legislative or judicial restrictions are realized, they will create significant new supply and demand in the secondary market.

Changes in Utility Structure

Several fundamental changes could affect both the primary and secondary SWU markets, such as basic changes in the structure and buying patterns of SWU customers, evolution of new technology, and entry into the market of private enrichment suppliers. There currently are only two utilities in the world which purchase all of their SWU requirements on the spot market. Their strategy has been quite successful; as spot market buyers, they have been able to purchase their enrichment services at discounts of 30 to 40 percent below long-term contract prices and 10 to 20 percent below DOE incentive prices. Given the savings that are possible by buying in the spot market, and forecasts of continuing overcapacity, one may wonder why any DOE requirements contract holders signed the USEC, and whether utilities are likely to sign long term contracts again in the future. The answer, at least in the USA, lies in the current utility regulatory structure, which allows utilities to pass on all "prudent" costs, and discourages risk taking. Essentially, this means that the utility rate commissions pass on any savings to the ratepayers, but charge the utility shareholders with any mistakes. Since the commissions will never question the cost of DOE SWU, utilities have little incentive to make the extra effort needed to shop around for lower cost enrichment.

It seems likely that this purchasing mentality on the part of utilities, and its inherent economic inefficiency, will not continue into the 1990s. The "pass through" cost recovery structure, along with the utility monopoly on power generation, are being phased out. More electric power will be sold in a competitive market, where the utility which saves 30 percent on enrichment costs can either keep the money or reduce its electricity prices to enlarge its market share. Such a pricing structure already is in effect with Public Service of Colorado's Fort St. Vrain plant, and it has been proposed for Commonwealth Edison's Byron and Braidwood units and Pacific Gas and Electric's Diablo Canyon units.

Over the past several years, purchasing attitudes toward the secondary market and non-DOE SWU have been permanently changed. While only two utilities are willing to depend on the secondary market for their total enrichment supply, others now see it as a supplemental tool in their overall strategy to reduce fuel costs.

New Technology

Centrifuge enrichment technology is very capital intensive compared to the older gaseous diffusion process, but it has relatively low incremental operating costs. Nuexco estimates show diffusion plants' current operating costs to be in the range of $50 to $90 per SWU, and capital costs from $20 to $30 per SWU. By comparison, a centrifuge plant's cost structure would be reversed, with operating costs between $20 to $35 per SWU, including centrifuge replacement, and capital costs between $60 to $80 per SWU. The Atomic Vapor Laser Isotope Separation (AVLIS) process is projected to have both low operating and capital costs, perhaps $20 per SWU for each. Once a centrifuge or AVLIS plant is operating, any uncontracted production capacity will likely be very competitive on the spot market, where recovery of full capital costs is not necessary.

While plants using the new technologies will be most efficient at full capacity, their utility customers need enrichment flexibility due to the unpredictable nature of their fuel requirements. The spot market would fill a need here, as it has in the uranium business. Facilities with low operating costs could either overcommit their production and fill their peak needs with spot market purchases, or size their facilities for peak loads and sell the excess in the spot market. The Urenco facilities currently are fully loaded under their long term contracts, but if Urenco is unable to deliver its planned production to customers, we would expect to see those customers in the spot or secondary market.

Privatization of the US Enrichment Business

For purposes of this discussion, privatization of enrichment services in the USA does not mean a government-corporation takeover of the existing DOE gaseous diffusion enrichment facilities. Under such an action, the corporation would merely inherit many of the problems facing the current DOE enrichment enterprise. It would take over an operation with high incremental costs, high sensitivity to energy prices, operating at a low fraction of capacity, and with customers who have been promised SWU prices below cost. If the dollar remains weak, this "private" corporation would be able to compete effectively with Eurodif, and its cost

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structure would support requirements contracts. However, this corporation could not be expected to introduce renewed competition into the enrichment industry, as it will likely delay the introduction of new technology in order to protect its investment in the existing diffusion plants.

True privatization requires the construction or completion of new enrichment facilities by private entities not connected to the US government. Examples of this are the American Enrichment Company's proposal to complete and operate the existing DOE Gas Centrifuge Enrichment Plant (GCEP) facility, and Urenco's idea of building a new centrifuge plant in the USA. If allowed, these plants could be in operation by about 1995, or perhaps even earlier if market conditions warrant. Unless the prospective private enrichment facility can and will sell SWU at a price lower than DOE's incremental costs of production, it shouldn't even try to enter the business.

The primary obstacle to the entry of a private enrichment company is the lack of a market. The total uncontracted demand (Figure 4) will have to be divided between existing primary enrichers, the secondary market, and the private enrichment services. Until their reliability is established, private enrichers probably will have to sell at secondary market prices, which will reduce their profit margins. However, without the secondary market the private enrichers may have no market at all. Even in the absence of a secondary market, private enrichment services still probably would have to meet DOE's incentive prices to capture any business.

There is even a possibility that existing primary suppliers will buy in the secondary market or from private producers to meet their contractual commitments if prices are lower than their incremental costs. This situation occurred in the uranium market in the early 1980s, but it is unlikely for SWU, considering the political pressures that will probably be exerted to keep the government plants open.

Gas centrifuge enrichment plants have high fixed costs. The private companies which use this technology certainly will attempt to obtain fixed commitment contracts at fixed prices, to reduce the financial risks. However, this may not be possible in the current buyers' market. To enter the business, private companies will have to have adequate financial backing to construct enrichment plants without guarantees of future income. This could be an insurmountable hurdle without government intervention in the form of financial guarantees. But assuming that their operation is assured, the secondary market will be one of the best vehicles for those suppliers to aggressively build market share.

Choices for the Future

The entry of at least one new company into the US enrichment field will be required to give customers the benefit of healthy competition. It is very unlikely that any new player will be able to assure its financial backers of income for at least 5 and perhaps 10 years, and even then, technical obstacles and potential government policy changes, under yet-to-be elected administrations, introduce additional risks. Yet, without the emergence of a new company, most DOE customers will not terminate their USEC contracts, further reducing the potential market for the 1990s.

It is obvious that the US government must decide on a consistent long-term strategy for its enrichment enterprise. It could simply harvest its business, by increasing prices and eliminating research. Or, by reducing prices and developing low cost processes it could maintain its overall market share with little change. A third alternative would be to expand, by undercutting prices and aggressively developing new processes. Today, by reducing prices, but eliminating research and development, DOE seems to have no strategy. If, however, DOE decides to maintain or expand its business, then there will be little room for private investment in enrichment.

If the US objective is to maintain enrichment capability and technology leadership, the best strategy might be to harvest the investment in its existing diffusion plants, providing the best economic return on that investment, while giving private industry incentives to develop a more cost efficient technology. This could take the form of an agreement similar to that for co-generated power, to purchase all of the SWU produced by the private enrichers at a price equal to the incremental costs of diffusion enrichment. Given a base load with DOE, private producers would be able to obtain lower-cost financing and compete aggressively in the world secondary market. They could then establish their credibility as the primary market is opening up in the mid-1990s.

Conclusion

In the 1970s, the assignment of utilities' Adjustable Fixed Commitment contracts created a market to provide an efficient means for exchange of SWU delivery commitments between utilities with excess and those with needs. In the same way, the secondary SWU market was a result of excess SWU produced under fixed commitment contracts, both by DOE and by Eurodif.

Today, both DOE and Eurodif have cut back production to

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reduce excess SWU, reducing the need for this secondary market. The secondary market's current function is to provide a mechanism for transferring the remaining excess inventories and purchase commitments and, to some extent, for selling USSR-produced SWU. In the 1990s, the secondary market may evolve into a spot market for selling SWU from the USSR and from other unestablished but low cost sources, such as private producers.

The primary SWU business still is in the hands of governments and government-owned corporations. Its history has shown that when governments try to set policy using commercial enterprises, they can generate gross economic inefficiencies. These same governments may again produce the inefficiencies which sustain the existence of a major secondary market.

Utilities which have not signed long-term contracts have realized reductions of up to 40 percent in their enrichment costs through participation in the secondary SWU market. For this reason, all utilities should consider reducing their long-term contract commitments so that they can continue to take advantage of the secondary market and the excess production capacity in the primary market.

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RECENT DEVELOPMENTS

JAPAN

Seven Japanese utilities recently have concluded their annual price negotiations with South Africa's Nuclear Fuels Corporation (NUFCOR), for uranium delivered under long-term supply contracts. The utilities agreed to pay approximately US$ 30.50 per pound U_3O_8 for fiscal year 1988 deliveries (ending March 31, 1989), the same price agreed upon last year for FY87 deliveries. The agreement was a compromise following a temporary breakdown in negotiations; NUFCOR had wanted to increase the price, despite the continuation of low spot prices, possibly hoping to take advantage of the continuing strength of the Japanese yen relative to the US dollar.

The annual price negotiations are influenced by spot and near-term uranium prices prevailing over the previous year, and the limited movement in prices provided insufficient rationale for raising the negotiated price. During the period covered by delivery contracts for FY82 to FY87, the negotiated delivery prices have dropped from $37.75 to $30.50. Table 1 shows a comparison of annually negotiated prices to average Nuexco Exchange Values for the past eight years.

* * *

Tokyo Electric Power Company (TEPCO) has announced firm plans to begin construction of Kashiwazaki-Kariwa Units 6 and 7 in 1991 and 1993, respectively. TEPCO has chosen General Electric Corporation's (GE) advanced BWR design for the plants, which together are estimated to cost approximately $4.5 billion. GE will provide the nuclear boiler systems, turbine generators, and the initial cores, at a cost of about $1 billion.

The 1,356 MWe (gross) plants will be the largest capacity BWRs outside the USSR, exceeded in size only by the 1,500 MWe RBMK unit at Ignalino in the USSR. Of its 32 commercial nuclear plants, Japan currently operates 16 BWRs based on earlier GE designs, which GE licensed to Toshiba and Hitachi for construction. The current order is part of a long-term development venture between GE and the two Japanese firms, and incorporates internal recirculation pumps that eliminate the requirement for large external recirculation pumps and piping.

The Ministry of International Trade and Industry (MITI) in April approved the installation program for TEPCO's Kashiwazaki-Kariwa Units 3 and 4 (1,100 MWe BWRs), which are scheduled for construction in July 1987 and February 1988, respectively. TEPCO expects the units to begin operating in July 1993 and July 1994.

Table 1

RESULTS OF ANNUAL JAPANESE-NUFCOR URANIUM PRICE NEGOTIATIONS COMPARED TO NUEXCO EXCHANGE VALUE

Fiscal Year Starting April 1	Approximate Agreed Price ($/lb. U_3O_8)	Average E.V. for Preceding Year ($/lb. U_3O_8)	Ratio of Delivery Price to Average E.V.
1981	45.00	41.17	1.1
1982	37.75	28.63	1.3
1983	35.50	23.65	1.5
1984	33.70	19.65	1.7
1985	33.50	22.10	1.5
1986	32.50	16.44	2.0
1987	30.50	15.94	1.9
1988	30.50	16.12	1.9

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NUEXCO

RECENT DEVELOPMENTS

* * *

Japanese utilities' profitability increased substantially during fiscal year 1986, ending March 31, 1987. Average pre-tax profits increased by more than 25 percent over the previous fiscal year (Table 2). Chubu Electric Power Company (EPC) showed the highest increase in profit level since FY85, 56.8 percent, and Tohoku EPC reported a 41.2 percent increase. Only Chugoku and Hokuriku EPC's profitability declined compared to the previous fiscal year. A large part of this profit, however, is due to the steady rise in the yen over the past year, and the related decline of the US dollar, which effectively have reduced dollar-denominated costs, such as oil, while leaving a greater percentage of revenues (in yen) for profit. This phenomenon is not expected to continue in the future. Despite much increased profits, overall sales of electricity declined more than two percent, primarily to Japan's industrial sector.

Table 2

JAPANESE UTILITY FY86 PROFITS[1]

Electric Power Company, Inc. (EPC)	Pre-tax Profit in FY ended 3/31/87	Profit Compared with Previous Fiscal Year (percent)	Gain Due to Yen/Dollar Exchange Rate
Hokkaido	439	+ 26.0	210
Tohoku	1,260	+ 41.2	1,367
TEPCO	4,440	+ 29.1	6,532
Chubu	3,226	+ 56.8	4,120
Hokuriku	453	- 17.8	394
Kansai	2,791	+ 21.2	2,720
Chugoku	701	- 12.5	930
Shikoku	510	+ 2.7	367
Kyushu	1,132	+ 12.0	1,055
Total/Average	**14,957**	**+ 25.6**	**17,695**

[1]All prices in 100 million yen

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DECOMMISSIONING OF NUCLEAR PLANTS, Part I

Introduction

Between now and the end of the century, nuclear plant decommissioning will become an issue of increasing importance to the nuclear power industry, and to the public in those countries that employ nuclear energy. By the year 2000, more than fifty currently operating commercial nuclear plants will have been in operation more than 30 years, and eight others will have exceeded forty years of operation. It is possible that many plants will be able to secure extensions to their operating licenses, enabling them to operate for additional periods. However, the economic, social, and political variables that could influence the granting, or even the desirability, of such extensions are difficult to predict.

At present, there are ongoing decommissioning projects in several countries, particularly in Canada, France, the Federal Republic of Germany (FRG), Japan, the United Kingdom (UK) and the USA. However, the projects currently being undertaken, while valuable for development of technology and experience, tend to involve much smaller, less radioactive situations than will be found in dealing with large commercial units.

Because much of the radioactivity found in nuclear plants will decay to near background levels within the first 100 years after shutdown, one much-discussed option involves entombing, or sealing the plant's reactor in concrete for up to 160 years or more. Another option is called "safe-storage," in which the unit is partially dismantled and decontaminated, and guarded for 40 to 50 years, before attempting to segment and remove the reactor's pressure vessel, internal parts, and containment structure.

At present, public awareness and understanding of the details of nuclear plant decommissioning is limited, and the public's reaction to such long-term choices is unknown. Immediate dismantling, however, poses the greatest radiation risks to the public and may not be technically achievable or economically feasible for some time, at least where large commercial power reactors are concerned. In addition, the problems posed by waste disposal have not been solved, either in the USA or in most other nuclear nations. Part One of this article examines past, present and near-future decommissioning projects in several countries, and discusses social and political trends that could affect continuing nuclear plant operations.

Stages in Plant Decommissioning

The word *decommissioning* is rather vague, and often is used to describe a wide variety of possible plant conditions following final reactor shutdown, over what is potentially a very long period of time. A given plant may alternate several times between phases of active work, in which equipment is being removed, decontaminated, and hauled away for disposal, and times when no work is being done. To add to the confusion, some persons or organizations may refer to a plant as *undergoing decommissioning* as soon as final shutdown takes place, while others may use the phrase only while work is actively being done. At any rate, the decommissioning process seldom is a smooth chronological sequence going straight through from plant shutdown to final removal of the last piece of equipment or structure. This article considers the process of decommissioning to begin with final fuel removal, continuing through complete removal of all equipment and structures until the site can be released for unrestricted access.

The owners of a nuclear plant may decide to terminate its operation, and therefore decommission the unit, for many reasons. The plant's operating licence may expire, and possible extensions may not be realistic or economic due to extensive necessary repairs, or upgrading for regulatory reasons. A plant may have become only marginally profitable to operate, or its small size may not be cost-effective relative to larger, more modern units. In some cases, equipment failure or other incidents may have reduced capacity, and repairs are too expensive to justify. Or, social pressures against nuclear power may result in governmental decisions to terminate operations at certain plants, either at the end of a license period or on some arbitrary timetable.

Much of the recent literature on decommissioning uses the concept of three standard phases, or stages, to categorize levels of decommissioning of a nuclear plant. Some plans only include activity up to a certain stage, with scheduling of further stages deferred, perhaps indefinitely.

Stage I begins immediately following plant shutdown, and includes removal of the reactor's fuel and securing of the plant for an indefinite period in a non-operating condition. The reactor's systems are drained of liquids (or gases), and most of the plant's electrical and mechanical equipment is taken permanently out of service. The mechanical openings to the containment structure are sealed, and the atmosphere inside the containment is controlled. Some decontamination of auxiliary systems or areas may be undertaken. Basically, Stage I refers to "mothballing" because little actual equipment removal is attempted. Access to the reactor and reactor site is controlled, with the operators maintaining regular monitoring and surveillance of the radiological and physical plant environs.

Leaving a reactor at Stage I for a chosen period of time requires less initial work, lower initial costs, and should result in lower occupational radiation exposures compared to

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quickly proceeding further in the decommissioning process. However, the long-term continued restriction of access to the site, and the relatively high level of continuing surveillance and monitoring are disadvantages.

In *Stage 2*, all equipment and some or all buildings external to the biological shielding are removed, and decontaminated if necessary, and reactor fuel is removed from the site. In this condition, plant activity, including monitoring, maintenance, and other normal activities, can be greatly reduced. The containment structure may be maintained intact as the principal barrier to access, or it may be decontaminated and removed, as deemed necessary for radiological safety.

It is at this stage that *entombment* may be chosen as an option for long-term storage. Entombing the reactor usually means sealing it in reinforced concrete or some other material until radioactivity has diminished to the point where workers can carry out many operations without the need for remote-controlled equipment (probably about 100 years after plant shutdown). Entombment may include the containment building, but more usually means sealing the reactor pressure vessel and its external shielding, allowing most or all external equipment to be removed.

Stage 3 represents the total dismantling and removal of the complete plant, including the reactor vessel and its internal parts, and disposing of all materials. The site may then be released for general, unrestricted use.

Full decommissioning assumes that most or all plants to be decommissioned will be taken through Stage 3, and eventually be completely removed. Simply describing the stages, however, does not account for the various possible timeframes leading to the Stage 3 condition. Even "immediate" dismantlement, for example, implies only that disassembling the reactor occurs within 10 to 15 years after shutdown. Following fuel removal, the owner could choose to store the reactor for long periods between the various states of disassembly. In particular, once the procedure reaches the Stage 2 condition — an intermediate level of disassembly — the owner may decide to maintain the reactor for a prolonged period in that condition, or entomb the plant, awaiting eventual dismantlement.

The three stages each present different advantages and disadvantages of cost, radiation exposure, political and social acceptability, and regulatory compliance. Of the three options, immediate dismantlement poses the greatest radiation risk to the public, the greatest technical challenges, and therefore the highest costs. Technically, the most attractive alternatives are those providing for a natural decrease in radiation to a point where remote-controlled equipment is only needed for limited operations. However, the long periods of entombment or long-term storage could provoke a significant social controversy.

Near-Term Decommissioning Possibilities

In the first decade of commercial nuclear power, from 1956 to 1965, 27 commercial reactors entered service in the West. Of these units, twenty were built in the UK, three in France, and two each were built in the USA and Italy (the USSR also built eight commercial reactors during that time). These early plants are small by today's standards and for technical reasons, most of these first-generation nuclear units are not likely to operate beyond their license periods and design lifetimes (typically 30 to 40 years). In the UK, particularly, a number of plants may have to be retired in the near future if license extensions are not granted. It is possible that many of these first-generation plants will be removed from service by the end of the century.

As a result of the boom in plant orders in the 1960s, between 1966 and 1975 over a hundred nuclear power plants entered commercial operation in the western world. Improved materials, advances in plant design and economics allowed and motivated the building of increasingly larger plants. These improvements may possibly allow extensions in operating lives, which in turn would delay the time before decommissioning is required.

During the third nuclear decade, from 1976 to 1985, nearly 170 more units entered commercial operation in the western world. Table 3 shows numbers of currently operating plants, by country, that entered service during the period 1955 to 1985. Figure 6 shows numbers of plants (operating as of the end of 1986) that will have exceeded 30 and 40 years of commercial service in years to come.

Assuming that none of the plants now operating are retired before 2000, there would be, by that date, over 50 plants whose operating age exceeded 30 years. Eight of those, all in the UK, would be over 40 years old. By 2010, almost 200 of the plants now operating will be over 30 years old, and more than 50 of today's plants will have seen greater than 40 years of operation. By 2015, nearly 300 commercial reactors will have exceeded the 30-year figure, and about 125 of those will then be over 40 years old. Thus, even if plants are able to reach 40 years of operation, there still will be a large number of units nearing retirement in the first decade of the next century.

Decommissioning Projects — Past and Present

To date, over sixty reactors have been partly or fully decommissioned in the USA alone, in addition to at least forty in other countries. Most of these units were small research or test reactors a fraction of the size of today's large commercial units, and few of these have been fully dismantled. The preferred options have been mothballing or

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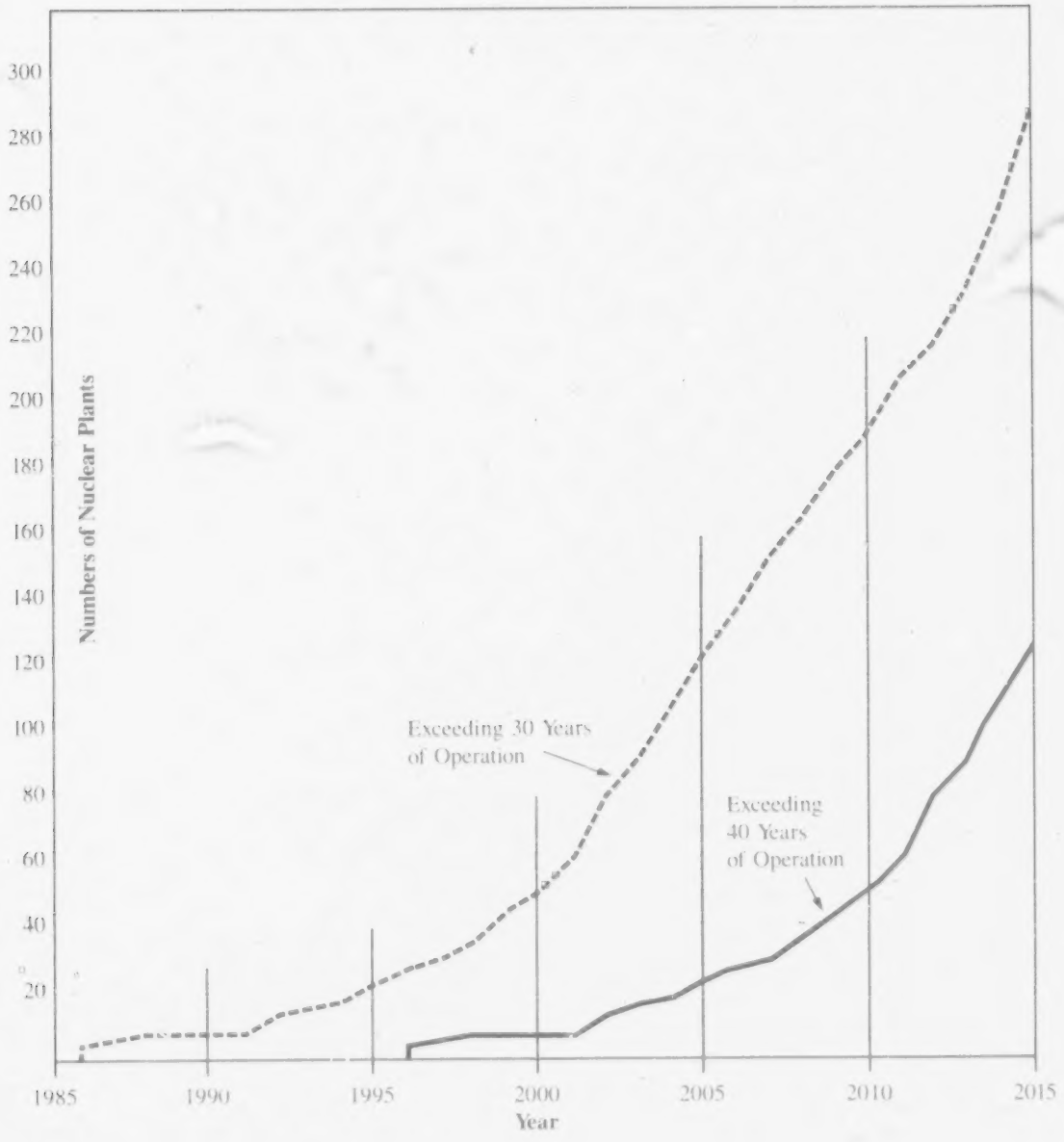
Figure 6

NUMBERS OF CURRENTLY OPERATING NUCLEAR POWER PLANTS WHOSE OPERATING LIFETIME WILL EXCEED 30 AND 40 YEARS BY 2015



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entombment. Table 4 lists some of the decommissioning projects that have been carried out to a given, planned stage; Table 5 lists some projects undergoing or awaiting decommissioning.

Canada — Two Canadian reactors have been undergoing decommissioning, Hydro Quebec's Gentilly Unit 1 (250-MWe CANDU), and Ontario Hydro's Douglas Point (235-MWe CANDU). Both units were built by Atomic Energy of Canada Limited (AECL). Gentilly Unit 1 began commercial operation as a prototype in 1971 and operated intermittently until 1979, when the need for repairs caused the plant's shutdown. In 1983, AECL decided to decommission the unit by sealing off the reactor building, bringing the plant to a "static state." Since completion of this Phase 1 condition in 1986, AECL anticipates deferral of dismantlement for at least 50 years. The Douglas Point reactor operated from 1968 to 1982. Decommissioning started in 1985, and spent fuel is scheduled for transfer to storage canisters in mid-1987.

Table 3

**CURRENTLY OPERATING NUCLEAR PLANTS[1]
ENTRY INTO COMMERCIAL SERVICE,
1955 to 1985**

Country[2]	1955-1965	1966-1975	1976-1985
Argentina		1	1
Belgium		3	4
Brazil			1
Canada		4	10
Finland			4
France		6	34
FRG		7	14
India		3	3
Italy	2		1
Japan		10	23
Korea			4
Netherlands		2	
Pakistan		1	
South Africa			2
Spain		3	5
Sweden		4	8
Switzerland		3	2
Taiwan			6
United Kingdom	20	7	10
USA	2	49	37
TOTAL:	24	103	169

[1]Does not include nuclear power plants that have been taken out of service or decommissioned.
[2]Includes only the World Outside the Centrally-Planned Economies Areas (WOCA) countries.

France — The French reactor program includes a number of past, present and future decommissioning projects. Some of the major projects include the following:

1. Electricite de France's Unit G-1, a carbon dioxide-cooled heavy water-moderated reactor at Marcoule (46-MWt GCR), operated from 1956 to 1975. Decommissioning through Stage 2 will take place between 1986 and 1990.

2. The Marcoule station's G-2 and G-3 units (40-MWe GCRs) operated from 1958 to 1980 and from 1959 to 1984, respectively. Unit G-2 is scheduled to begin decommissioning in 1990 and Unit G-3 in 1995, both to the Stage 2 condition.

3. The Rapsodie 40-MWt fast breeder experimental reactor also is expected to undergo decommissioning procedures between 1987 and 1990. It entered service in 1967 and was shut down in 1982.

4. Chinon Unit A1 (80-MWe GCR) began operation in 1963 and was shut down in 1973. The reactor building and piping have been isolated, and the unit currently is at Stage 1 condition.

5. Chinon Unit A2 (230-MWe GCR) operated from 1964 to 1985. Plans for its decommissioning have not been made public.

Other French reactors involved in, or scheduled for decommissioning include the EL research units 2, 3, and 4 at Saclay. Unit 2 operated from 1952 to 1965, Unit 3 from 1957 to 1979, and Unit 4 from 1966 to 1984. Units 2 and 3 currently are at Stage 2 condition. Unit 4, the largest of the three plants at 70 MWe (Units 2 and 3 are rated at 2.8 MWt and 18 MWt, respectively) has not yet undergone decommissioning.

Decommissioning of several other small test reactors, such as the AOE, Nereide, Minerve, and Triton units at Fonteney, and the Peggy, Cesar, and Pegase units at Cadarache, has been carried out to Stages 2 or 3 over the past decade. The largest of these was the Pegase reactor (a 35-MWt research reactor), which operated from 1962 to 1975 and has been completely dismantled, leaving its building free for storage uses. Commercial plants Chinon Unit 3 (a 480-MWe GCR which entered service in 1967), and St. Laurent Unit 1 (a 480-MWe GCR which entered service in 1969) also reportedly could soon be shut down. In general, France's policy on reactor decommissioning aims for reasonably rapid progress through Stage 2, at least for reactors where the presence of a containment structure allows for relatively easy long-term storage, with indefinite postponement of total dismantlement.

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Federal Republic of Germany — In the FRG, one major project is underway and another is scheduled to begin soon. The Niederaichbach reactor, a 100-MWe gas-cooled heavy-water reactor at Karlsruhe, only operated over a period of two years (producing power for less than three weeks), from 1972 to 1974, before technical problems caused its closure. It has been licensed for decommissioning since 1985, and currently is scheduled to reach Stage 2 condition by 1992. The 250-MWe (BWR) Gundremmingen Unit A, owned by Kernkraftwerk RWE-Bayernwerk GmbH (KRB), recently has received its decommissioning license. This unit operated from 1966 to 1977, and was shut down after the owners judged costs of repair and upgrading, following a coolant leak incident, to be uneconomical.

Other units scheduled for decommissioning include Rheinisch-Westfaelisches Elektrizitaetswerk AG's (RWE) 15-MWe BWR located at Kahl (the FRG's first nuclear power plant), and Kernkraftwerk Lippe-EMS GmbH's (KLE) Lingen plant (256-MWe BWR, located at Emsland), which operated from 1968 to 1977. The Karlsruhe multi-purpose research reactor (MZFR, a 58-MWe PWR), in service from 1965 to 1984, also is scheduled for decommissioning. In addition, between 1980 and 1982, the nuclear-powered ship Otto Hahn's reactor was dismantled, with its internal parts placed in safe storage, after ten years of operation.

Japan — Several decommissioning projects are underway or planned in Japan. Because of the need to make the maximum use of land space in Japan, participants in the Long-Term Program on Development and Utilization of Nuclear Energy formulated a policy under which reactors should be completely dismantled as soon after shutdown as practical. This generally means a short period of mothballing or entombment prior to dismantlement, but should mean that reactors are dismantled within 10 to 15 years of shutdown. Several organizations, including the Japan Atomic Energy Research Institute (JAERI) and the Nuclear Power Engineering Test Center, in addition to several of Japan's large industrial companies, are actively developing the necessary

Table 4

PAST DECOMMISSIONING PROJECTS[1]

Reactor	Year Decommissioned	Country	Type	Capacity (Gross MWt)[2]	Stage
Gentilly 1	1985	Canada	CANDU	250(e)	1
EL 3	1986	France	HWR	18	2
Pagase	1978	France	MTR-LW	35	3
Chinon A1	1980	France	GCR	80(e)	1
NS Otto Hahn	1981	FRG	PWR	38	3
BONUS[3]	1970	Puerto Rico	BWR	50	2
Agesta	1975	Sweden	PHWR	80(e)	1
Lucens CNL	1969	Switzerland	GCHWR	30	3
BEPO	1968	UK	Graphite	6(e)	2
CTVR[4]	1968	USA	HWR	65	1
Elk River	1968	USA	BWR	58	3
Hallam	1968	USA	Graphite	256	2
Piqua	1969	USA	Organic	45	2
Pathfinder	1972	USA	BWR	190	1
Saxton	1973	USA	PWR	23	1
Fermi 1	1975	USA	FBR	200	1
Peach Bottom 1	1978	USA	GCR	115	1
SRE[5,6]	1982	USA	Graphite	30	3

[1]Includes only major projects or projects of interest. List is not exhaustive or all inclusive.
[2]Megawatts of thermal capacity. (e) indicates electrical capacity.
[3]Boiling Nuclear Superheat Reactor.
[4]Carolina Virginia Tube Reactor.
[5]Sodium Reactor Experimental Facility, California.

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Table 5

NUCLEAR REACTORS AWAITING OR UNDERGOING DECOMMISSIONING

Reactor	Year Started	Year Shut down	Country	Type	Capacity (Gross MWe)[1]
Douglas Point	1968	1982	Canada	CANDU	206
G1 Marcoule	1956	1975	France	GCR	46(t)
G2 Marcoule	1958	1980	France	GCR	45
G3 Marcoule	1959	1983	France	GCR	45
Chinon A2	1965	1984	France	GCR	230
EL-4	1966	1984	France	HWR	70
Rapsodie	1967	1982	France	FBR	40(t)
Karlsruhe	1965	1984	FRG	PWR	58
Gundremmingen	1966	1977	FRG	BWR	250
Lingen	1968	1976	FRG	BWR	256
Niederaichbach	1972	1974	FRG	HWGCR	100
Garigliano	1964	1978	Italy	BWR	160
JRR 3[2]	1962	1983	Japan	HWR	10(t)
JPDR[3]	1963	1976	Japan	BWR	10
Windscale	1962	1981	UK	AGR	33
Shippingport	1957	1982	USA	PWR	72
Dresden 1	1960	1978	USA	BWR	210
Indian Point 1	1962	1974	USA	PWR	257
Humboldt Bay	1963	1976	USA	BWR	65

[1](t) indicates thermal capacity.
[2]Japan Research Reactor.
[3]Japan Power Demonstration Reactor.

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technologies, especially those involving robots. Current Japanese policy envisions that technological solutions to handling highly radioactive materials will be available in the late 1990s, about the time that the first large commercial reactors will be shut down.

1. In December 1986, JAERI began decommissioning procedures on the Japan Power Demonstration Reactor (JPDR), a 12.5-MWe (45-90 MWt) BWR located at Tokai-mura. The unit first generated electricity in October 1963, and operated until 1969. Following core modifications, power was doubled, from 45 MWt to 90 MWt, from 1972 to 1976, when the unit was shut down. Planning has been underway since 1981, in two main phases. In the first phase, efforts concentrated on development of dismantling technology and system engineering, and this phase was largely completed by early 1986. Phase 2 involves demonstrating the technology, and will continue until the reactor is completely dismantled in 1991.

This project is the focal point of Japan's research and development into decommissioning technology, including extensive use of robots, and the experimental use of a plasma-arc cutting machine to cut the reactor vessel. The project schedule calls for initial removal of equipment during the spring of 1987, followed by dismantling of the reactor's internal parts in late 1987. In 1988, JAERI will segment and remove the reactor pressure vessel and remaining equipment, and in 1989 will demolish the 1.5- to 3-meter thick concrete containment structure. By 1990, the reactor's primary containment vessel will be removed, leaving the site free for backfill and landscaping in 1991. From beginning development to final release of the land for unrestricted access, the decommissioning process will have taken ten years.

2. Japan's first nuclear reactor, JRR Unit 1 (50-KWt BWR), has been mothballed as a monument. JRR Unit 3, a 10-MWt heavy-water moderated reactor, operated for more than 20 years until being shutdown in 1983, and recently was moved, as a complete unit, into a nearby warehouse for long-term storage.

3. Tokai Unit 1, a 159-MWe GCR of the Magnox type owned by Japan Atomic Power Company Ltd., reportedly will be Japan's first commercial unit to be decommissioned. This plant began commercial service in 1966 and is scheduled to be shut down within the next few years.

United Kingdom — In 1981, the United Kingdom Atomic Energy Authority (UKAEA) began decommissioning of the 33-MWe Windscale advanced gas-cooled reactor (AGR), the prototype for the UK's 14 commercial AGRs. Only the reactor itself and the spherical containment structure will be removed; the UKAEA will continue to use the other buildings on site. To date, contractors have removed the machinery from the turbine building, and the UKAEA is making preparations to dismantle the pressure vessel, reactor core and containment.

The UKAEA and the engineering firm Strachan & Henshaw are jointly designing a remote-controlled cutting machine that will operate within the reactor vault, first cutting up the reactor's internals, then segmenting the pressure vessel. This phase of the project probably will take place between late 1991 and 1995. In terms of technology development and application, the Windscale project offers several advantages. While is is much smaller than the commercial units, the Windscale unit at least represents the UK's main reactor type, and it operated for 19 years, long enough to achieve radiation levels that approximate what will be found in later, commercial decommissioning projects. At least one of the UK's Magnox reactors is expected to be shut down in the 1990s, and the possibility exists for closure of several others. Eight Magnox units entered service between 1956 and 1958.

USA — In the USA, only four units that produced commercial electricity have been, or currently are being decommissioned.

1. The Elk River, Minnesota reactor (US Atomic Energy Commission, 22-MWe PWR) is the only one to have been completely decontaminated and dismantled. It operated for only four years, 1964 to 1968, and decommissioning was completed in 1974.

2. Peach Bottom Unit 1 (Philadelphia Electric Company, 40-MWe HTGR) entered service in 1967. The plant operated until 1975, when the utility decided close it for decommissioning. It currently is mothballed.

3. Fermi Unit 1 (Detroit Edison, 200-MWt PWR) was mothballed in 1975, after being shut down in 1972.

4. The 60-MWe Shippingport reactor, near Pittsburgh, Pennsylvania, was the USA's first commercial nuclear reactor, and also is the first US reactor to be decommissioned after a relatively long period of operation. The unit is owned by the Department of Energy (DOE) and the Duquesne Light Company. The unit started commercial operation in 1957 and operated until 1982. DOE and General Electric Corporation, the project's Decommissioning Operations Contractor, began decommissioning the unit in 1985, but are using a method that is unlikely to be repeated, particularly for commercial-scale units. After removal and decontamination of the external systems, the contractors will lift the reactor pressure vessel as a unit, and ship it to DOE's Hanford, Washington nuclear reservation for disposal, where it will be buried intact. This method will save about one year, compared to

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segmentation of the vessel and its internal parts, but unfortunately will provide only limited experience for future projects. The Shippingport project is scheduled for completion by mid-1988.

Thus far, the largest reactor to be decommissioned in the USA has been the 256-MWt Hallam unit in Nebraska, which was entombed in concrete in 1969. Other US reactors awaiting decommissioning include Dresden Unit 1 (Commonwealth Edison, 210-MWe BWR), which operated from 1960 to 1978, Indian Point Unit 1 (Consolidated Edison, 257-MWe PWR), which operated from 1962 to 1974, and the Humboldt Bay Unit 3 reactor (Pacific Gas & Electric, 63-MWe prototype BWR), in service from 1963 to 1976. PG&E plans to dismantle the Humboldt Bay plant in 2015, after 30 years of safe storage.

Both the Indian Point and Dresden plants are located at sites where other, newer reactors also are operating. Their situation typifies a dilemma that will be increasingly common as older plants are retired from operation. The probable solution in many cases will be to mothball or place those plants in Stage 1 condition, until the other reactors occupying the site also are permanently shut down.

Nuclear Plant Life Extension

A crucial factor in estimating the number of plants to be decommissioned in years to come is the possibility of gaining extensions for plants' operating licenses. There will be substantial economic pressure (and incentive) to maximize returns on generating plants, especially since investment in these plants will have been fully amortized as they approach the end of their operating license periods. Without extensions on plants' operating license periods, replacing the capacity lost by permanent shutdown — up to 50 gigawatts between 2002 and 2008 in the USA alone — will put an enormous financial burden on the electric power infrastructure.

In the USA, nuclear power plant design lifetimes generally are based on forty calendar years of operation, which is the maximum period of time allowed under NRC licenses. Presently, no rules prohibit application for an extension of this license. Prior to 1982, the NRC license period began with the issuance of the plant's construction permit; since 1982, the licensing period has begun with issuance of the plant's operating license. Since the construction time represents a significant part of the license period, and one which is highly variable from plant to plant, one path to life extension for plants licensed before 1982 is through recovery of licensed operating time lost during the construction process. Since 1985, the NRC has allowed requests by utilities to begin the license period retroactively from the date of low-power operation instead of the date the construction permit was issued. At least 14 nuclear units have thus far had their licenses extended, and a number of others have applications pending.

Another possible approach that would extend licensed operating time involves gaining back time lost through outages, whether for refueling or repair. Assuming a forty-year operating lifetime, an average availability factor of 75 percent would mean that ten years of operating time would be lost to outages, effectively reducing the operating lifetime by 25 percent, to 30 full-power years. While it seems relatively easy and straightforward to compensate for the construction period of a plant, assessing outage time is much more complicated. Transient reactor states — startups, shutdowns, scrams occurring under power, and other unusual events — may cause fatigue many times greater than that which occurs under steady operating conditions. Documenting plant condition under all transient states, in order to describe all outages for the purpose of recovering license time, could require considerably greater recordkeeping than is commonly the norm.

Even assuming that the NRC occasionally or even routinely grants license extensions, many economic factors govern whether a utility is justified in undertaking the extensive refurbishing and replacement of components that would allow, for example, a twenty-year license extension. Obviously, the investment/return balance must weigh in favor of the necessary investment, and that investment could conceivably require extensive upgrading within a then-tighter regulatory environment. Estimates of such reconditioning suggest costs between $100 million and $1 billion. Replacement of the reactor pressure vessel, for example, could cost up to $150 million. The potential return from twenty years of additional electricity generation could, however, be several times that amount.

It is impossible to predict the political, environmental, or regulatory climate that could affect approval for extensions in plant operating lifetimes in the next century. However, if even half of the plants whose current licenses expire between 2000 and 2010 can secure extensions, the effect on decommissioning schedules will be substantial.

Political and Social Factors

Plant age and condition naturally are primary factors in determining whether a reactor should be retired and decommissioned. Political and social considerations, however, are potentially extremely important variables that could result in early shutdowns not based on technical or licensing reasons.

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After accidents at Three Mile Island in 1978 and Chernobyl in 1986, extensive political debate focused on the desirability of nuclear power and its potential threat to public safety. These events led to new regulatory and legal initiatives and scrutiny that continues today.

The countries most affected by political and social opposition to nuclear power are the Federal Republic of Germany (FRG), Sweden, and Italy. In the FRG, the Green Party, in occasional partnership with the Social Democratic Party (SPD), often has stated its desire to close immediately all nuclear power stations in that country. Although the SPD-Green alliance did not succeed in taking control of the federal government in the January 1987 elections, their anti-nuclear political position did raise the issue of near-term decommissioning of existing plants, and, along with the accident at Chernobyl, provoked several serious economic studies into the feasibility of eliminating nuclear power in the FRG. The SPD's pre-election stand against nuclear energy called for full shutdown of all 18 of the FRG's nuclear plants by 1997.

Italy's three operational nuclear units face an even more uncertain future, and at present, none of those reactors are operating. The Latina and Caorso units are shut down for maintenance, although anti-nuclear public sentiment may be partially or wholly responsible for their not being restarted, and the Trino Vercellese plant is out of service for refueling. Trino's operating license expires in 1990, and there is a strong possibility that the unit will be retired at that time. The Latina and Trino reactors entered commercial service in 1963 and 1964, respectively, while Caorso began operating in late 1981. Italy's Garigliano reactor, a 160-MWe BWR that operated from 1964 to 1978, reportedly may soon begin the decommissioning process.

Swedish law has, since 1981, required the country to withdraw from nuclear power by 2010. Prime minister Ingvar Carlsson, however, has stated his intention to accelerate the process by closing nuclear plants in 1993 and 1996. No specifics have been mentioned, but over the last several years anti-nuclear protests repeatedly have targeted the Barseback station, which is only about 30 km from Copenhagen. This unit is the most likely candidate for early closure if it does occur. Whether any plants actually are closed ahead of schedule probably depends to a considerable extent on Swedish public opinion for or against nuclear power in the next few years. Political rhetoric aside, Sweden's nuclear units play an extremely important part in its electric power infrastructure. Since no economically acceptable alternatives to those nuclear plants are readily available, early plant closure appears unlikely at this time.

While it is unlikely that public opinion in the USA will actually force early nuclear plant closures, effective opposition to nuclear power could have a similar effect by making upgrading or reconditioning of marginal facilities not worth the cost. Tighter NRC and environmental regulations, and costly legal challenges over a wide range of issues could influence some utilities to simply close their older, more maintenance-intensive nuclear plants, perhaps even before their operating licenses expire. Minor, but costly, incidents could become major economic obstacles.

The nuclear power industry has not yet really confronted the public, and their political representatives, with the choices required by multiple nuclear plant decommissionings. Nor is the public really aware of the costs and technical challenges associated with fully dismantling even one large commercial reactor, much less tens or hundreds of them. Nuclear utility managers are accustomed to thinking in terms of decades — for plant construction, for fuel procurement contracts, and for return on capital investments. It may be much easier, then, for utility personnel to plan for decommissioning over the long term, meaning up to a century, than for the public to accept such a timeframe, especially where storing a large, highly radioactive plant is concerned. It would not be unrealistic to expect a strong clash of intentions where, for example, a utility presents its plans to the public to impound its retired reactor or reactors for 50 or even 100 years before attempting their disposal.

Conclusion

Worldwide, decommissioning of commercial nuclear reactors is just beginning. In the decades to come, however, the permanent shutdown of numerous commercial nuclear power plants will require extensive development of dismantling technology, as well as the cooperation (and education) of the public, who will have to accept the existence of reactors placed in various degrees of safe storage for long periods of time. Experience being gained today, and over the next few years in France, the FRG, Japan, the UK and the USA will provide the basis for safe and economic future decommissioning projects.

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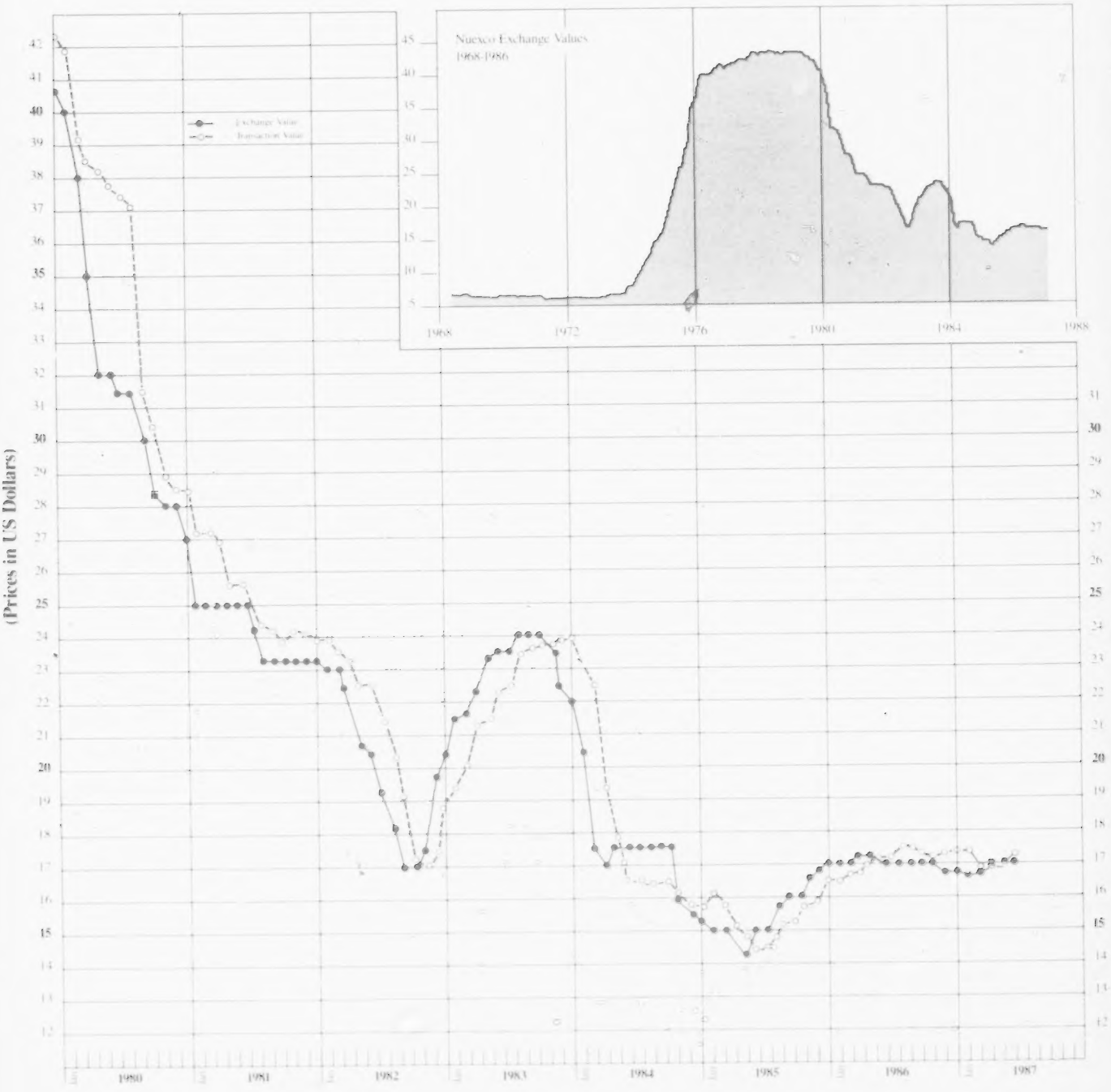
HISTORICAL MARKET DATA



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HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	**17.00**							

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	**17.20**							

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HISTORICAL MARKET DATA

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	**1.80**							

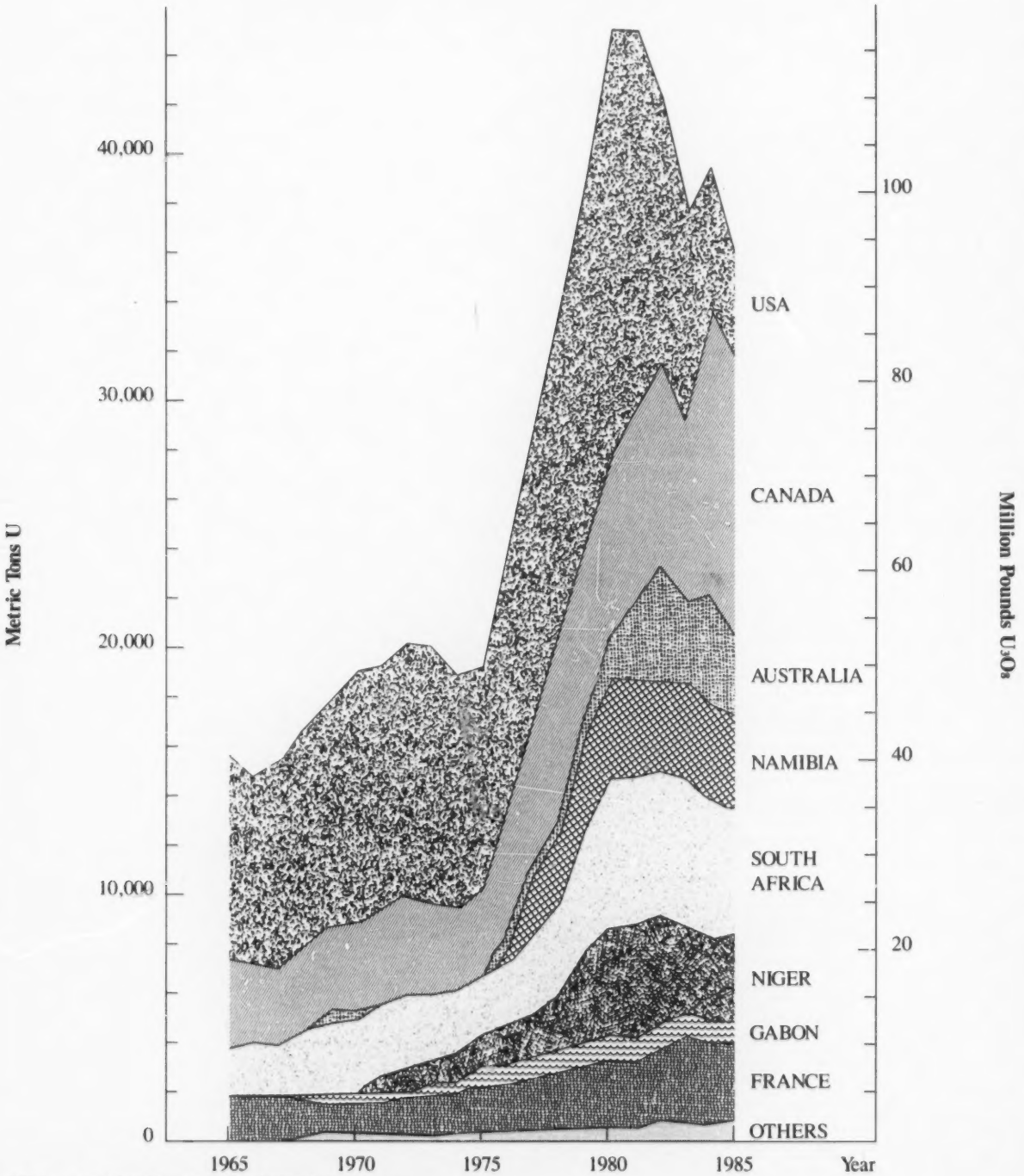
HISTORICAL UF_6 VALUES

Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	**47.75**							

HISTORICAL MARKET DATA

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



[1]WOCA = World Outside of Centrally-planned Economic Areas.

[2]1985 production data are preliminary.

[3]A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

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HISTORICAL MARKET DATA

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

[1]Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2]Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3]Excludes direct imports by domestic utilities.

[4]Includes imports by domestic utilities and domestic suppliers.

[5]Includes delivery commitments to domestic utilities and agents.

[6]Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

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VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

[1]The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2]The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3]For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4]Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

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GOVERNMENT STATISTICS

AUSTRALIA

	Consumer Price Index[1]	Price Index of Materials Used in Manufacturing Industry — All Groups[2] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[3] (1976 = 100)
1975 Avg.	57.9	150.4	132.6
1976 Avg.	65.7	168.4	160.9
1977 Avg.	73.8	192.0	179.0
1978 Avg.[4,5]	79.7	198.5	190.0
1979 Avg.	86.9	248.8	127.9
1980 Avg.	95.8	321.8	140.8
1981 Avg.	105.0	355.3	154.1
1982 Avg.[6]	116.7	368.6	174.9
1983 Avg.	128.5	401.6	181.8
FY84 Avg.[7]	133.6	95.3	—
FY85 Avg.[7]	133.6	100.0	—
FY86 Avg.[7]	—	105.0	—
Jan 1986	—	109.6	210.0
Feb 1986	—	108.7	210.0
Mar 1986	150.5	99.5	210.5
Apr 1986	—	94.3	210.5
May 1986	—	93.5	210.5
Jun 1986	153.0	95.7	210.5
Jul 1986	—	98.1	215.3
Aug 1986	—	98.2	215.3
Sep 1986	157.0	105.6	215.3
Oct 1986	—	106.2	215.4
Nov 1986	—	105.2	215.6
Dec 1986	161.5	105.5	215.6
Jan 1987	—	106.4	215.9
Feb 1987	—	109.2	216.5

P = Preliminary R = Revised since last month

[1]Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: year 1980-81 = 100.0). Index periods are for normal calendar years; figures shown at end of year represent yearly average; figures shown at end of quarter represent quarterly average.

[2]Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[3]Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[4]Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[5]Annual averages prior to 1979 reflect index base no longer in use.

[6]Monthly data for 1979-82 appear on page 35 of Report 184.

[7]Annual averages are for financial year ending June 30.

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CANADA

GOVERNMENT STATISTICS

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2] Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.4	19.32	16.62	15.78	13.14	11.45	12.90
Oct 1986	119.9	19.97	16.81	16.11	13.30	11.59	12.94
Nov 1986	119.9	20.11	17.01	16.24	13.42	11.66	12.93
Dec 1986	119.7	19.67	16.79	16.19	13.06	11.57	12.99
Jan 1987	120.0	19.52	16.84R	16.07R	13.06R	12.56R	12.95R
Feb 1987	119.8	20.33	17.15	16.09	13.01	12.66	13.18
Mar 1987	120.3	20.04P	17.06P	16.06P	12.85P	12.69P	13.06P
Apr 1987	120.8P	—	—	—	—	—	—

P = Preliminary R = Revised since last month

[1]Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2]Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3]Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4]Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5]Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6]Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7]Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8]Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

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GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
1985	Avg.	68.70	151.68	192.6	181.2	726,804	396,956
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772	511,363
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	761,325	531,509
Dec	1986	85.38	189.9	244.9	232.1	752,264	536,970
Jan	1987	—	—	248.3	233.9	740,031	532,577
Feb	1987	—	—	251.0	237.0	—	—
Mar	1987	88.17	197.1	255.0	239.6	—	—
Apr	1987	—	—	258.2	—	—	—

P = Preliminary R = Revised since last month

[1]Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly.

[2]Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3]Republic of South Africa Department of Statistics, Pretoria; "Government Gazette: Consumer Price Index for Urban Areas."

[4]The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5]Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6]Bulletin of Statistics, Department of Statistics, Pretoria.

[7]Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8]Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9]Monthly data for 1979-82 appear on page 39 of Report 184.

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UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2] (1967 = 100)	GNP Implicit Price Deflator[3,4] (1982 = 100)	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)			Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
1985 Avg.	323.9	308.8	322.2	111.7	13.39	13.75	11.56	9.47
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.9	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.7	297.5	330.2	115.0	13.11	13.41	12.03	9.73
Oct 1986	309.6	298.4	330.5	—	12.51	13.29	12.08	9.72
Nov 1986	309.8	298.7	330.8	—	12.57	13.27	12.15	9.75
Dec 1986	309.3	298.1	331.1	115.3	12.70	13.16	12.20	9.85
Jan 1987	313.6	300.9	333.1	—	12.80	13.10	12.17	9.86
Feb 1987	315.7	302.7	334.4	—	12.81R	12.95R	12.20	9.86R
Mar 1987	315.8	302.8	335.9	116.2	12.89P	12.90P	12.23R	9.85R
Apr 1987	317.4	305.1	337.7	—	—	—	12.32P	9.87P

P = Preliminary R = Revised since last month

[1]US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2]US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3]US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4]The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5]US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6]Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7]Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

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